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Furthermore, the fact that the intrabronchial injection of a minimum culture proved fatal only when the injection was made ten days after the section of one vagus and the further consideration of the fact that it takes about ten days for the degeneration of vasodilators lend support to the assumption that it is the degeneration of the vasodilators which is responsible for the fatal results observed in our experiments.

ON THE ETHOLOGY OF CHITON TUBERCULATUS[1]

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Communicated by E. L. Mark, September 5, 1919

Chitons of the species *C. tuberculatus* Linn. are an important element in the shore-fauna of the Bermuda Islands. Their large size, their abundance, and the diversity of the habitats which they occupy within the tidal zone, make them animals appropriate for a variety of investigational purposes—notably for study of the relations found among the features of local habitats, on the one hand, and, on the other, certain definite sensory and other modifications of these animals which develop with the advancing age of a chiton. The organization of the Placophora, probably primitive with reference to that of other molluscs, makes it important also to obtain physiological evidence as to the characteristics of the nervous system in these animals. On the structural side it is well known that the chiton central nervous system is in the form of strands, containing perikarya throughout their length, but with no concentrations of these cells into distinct ganglionic enlargements.

We find in *Chiton tuberculatus* decided indications of but a relatively incipient degree of nervous centralization. The autonomy of the several portions of the body, or of the parts into which it may be artificially separated, is conspicuous. At the sides of the body, the parts (girdle, ctenidia, etc.) innervated by the pallial strands are pronouncedly homolateral in their responses. The coördinating mechanism for the production of pedal locomotor waves is locally contained. The absence of strong anterior nervous centralization is nicely indicated by the exhibition of backward creeping (especially in Ischnochiton) under proper conditions of stimulation by light.

Of the several kinds of sensory receptors which we have distinguished in *Chiton tuberculatus*, the nervous elements in the shell tegmenta, now for the first time proved to be photosensitive, are perhaps the most important in determining the general habits of the animal. Through the mediation of the nervous elements of the shell-valves Chiton exhibits precise phototropic orientations. The younger individuals are photonegative, the older ones photopositive, to sunlight. Chitons of intermediate age are positive to weak daylight, negative to strong. The 'intermediate' age is generally in the neighborhood of six years (5 to 7 cms. length).[2] This alteration in the behavior of Chiton toward daylight as the animal becomes older is primarily responsible for the exhibition of a complex series of harmonious environmental interrelations. The progressive inversion in the sense of Chiton's phototropism is due to the elimination of the shell photoreceptors by erosion, thus conditioning in the older individuals a lower specific stimulating power of the light. Erosion of the shell is itself produced through normal growth effects, in part; more directly, by physical agencies of the environment and by the activities of various small organisms which come to live on the chiton shell.

The nature of the algal food, varying somewhat from place to place, and the presence of epiphytes, barnacles, tubiculous worms, and the like, on the dorsal surface of a chiton, determine automatically a certain degree of homochromic coloration. The established fact that a given Chiton tends to remain within a relatively small area for long periods, affords opportunity for the institution of correlations of this nature. These correlations concern practically every feature of the bionomics of Chiton: its method of feeding, its breeding habits, and other matters which have been studied; and they follow automatically in the wake of the changing phototropism of the animal, itself largely controlled by environmental causes. Granted the original condition that those inherited mechanisms for response present in the young post-larval chiton lead to its living under loosely piled small stones at the very upper limit of the tide, it can be shown that the 'adaptive' cycle of subsequent changes, leading ultimately to the life of the oldest individuals on brilliantly illuminated rock surfaces, is produced in automatic sequence. It is important that the environmental effects of a particular location are in general not such as to cause a chiton to become more closely adapted to the peculiarities of that situation, but on the contrary result in the animal's going somewhere else—namely, into a more brightly illuminated area, where the environment as a whole is in certain respects fundamentally different.

From the standpoint of the theory of adaptation, the most important result of our inquiry into the natural history of Chiton may be given thus:

a number of precise and intricate bionomic correlations result automatically from the animal's modes of reaction, mediated by a central nervous apparatus which is relatively diffuse, less centralized functionally than is that of other molluscs; the habits so expressed determine the nature of the environment in which the Chiton lives.

Full reports of these studies will be found in papers to appear in the *Journal of Experimental Zoölogy*, and in the *American Naturalist.*

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[1] Contributions from the Bermuda Biological Station for Research, No. 112.

[2] cf. Crozier, W. J., These PROCEEDINGS, November, 1918.

THE NERVOUS ORGANIZATION OF A NUDIBRANCH[1]

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Having in mind the important position of the mollusca with respect to the evolutional elaboration of central nervous organs, we have sought to obtain evidence permitting a more precise statement of the functional relations between the peripheral and the ganglionic conducting pathways in a nudibranch, *Chromodoris zebra*. The absence of a shell in these animals, and certain more specific peculiarities of their construction, afford favorable conditions for such analysis. A full account of our observations is in press, to appear in the *Journal of Experimental Zoölogy.*[2]

The dorsally placed 'crown' of gills comprises in *Chromodoris* about 12 distinct plumes arising from a ridge almost surrounding the anal aperture. Each plume may contract independently. All of the plumes may also contract simultaneously, and the whole gill-crown may be concealed within a collared pocket. During the day-time, and under certain conditions of alkalinity and temperature in the seawater,[3] the plumes are extended. If a plume be lightly touched at one point, the common orm of response is constriction at that level, resulting in a slight swaying of the plume. More vigorous stimulation likewise leads to this locally confined unsymmetrical contraction, which however is now seen to spread distally from the site of activation, as a collapse and shrivelling of the plume, and is also accompanied by the downward pulling of the entire plume through the traction of muscles situated in the basal tissue of the gill-crown. Still stronger activation induces longitudinal shortening of the plume, both distally and proximally to the point of stimulation, and in the basal tissue.[4]